Claims

What is claimed is:

1. A method for providing adaptation of an antenna array in a base station associated with a cell of a cellular wireless communication system, comprising the steps of:

estimating a spatial covariance matrix for each of a plurality of mobile stations communicating with the base station, the spatial covariance matrix for a given one of the mobile stations being determined at least in part based on a unique hopping sequence of the mobile station and providing a correlation between signals received from the mobile station at different antenna elements within the antenna array;

processing the estimated spatial covariance matrices to generate an estimate of an interference matrix for the plurality of mobile stations;

estimating an array response for the given mobile station from the interference matrix;

processing the array response for the given mobile station to generate an antenna weighting associated with the given mobile station; and

applying the antenna weighting to a signal received from the given mobile station in order to facilitate detection of a corresponding transmitted symbol.

2. The method of claim 1 wherein the cellular wireless system comprises an orthogonal frequency division multiplexed (OFDM) system with spread spectrum multiple access (SSMA).

3. The method of claim 1 wherein the antenna array comprises M antenna elements, and the spatial covariance matrices and the interference matrix each comprise an $M \times M$ matrix.

4. The method of claim 1 wherein the array response comprises a scaled array response vector.

5. The method of claim 1 further including the steps of selecting initial estimates for the interference matrix and the array responses for each of the plurality of mobile stations, and subsequently applying a designated number of iterations of an iterative algorithm to determine final estimates of the interference matrix and the array responses for each of the plurality of mobile stations.

6. The method of claim 1 wherein the step of estimating the spatial covariance matrix for each of the plurality of mobile stations further comprises computing a spatial covariance matrix $\hat{\mathbf{P}}_Z(k)$ of a signal $\mathbf{z}(t,k)=\mathbf{y}(t,\sigma(t,k))$, where t denotes a particular symbol period, $k = 1, \ldots K$ denotes a particular one of K mobile stations communicating with the base station within the symbol period, $\mathbf{y}(t,n)$ denotes the received signal for symbol period t and tone index $n = 1, \ldots N$, and $\sigma(t,k)$ denotes the unique hopping sequence for the kth mobile station.

7. The method of claim 6 wherein the spatial covariance matrix $\hat{\mathbf{P}}_Z(k)$ is estimated for the kth mobile station after receipt of T symbols of data in accordance with the following equation:

$$\hat{\mathbf{P}}_Z(k)=\frac{1}{T}\sum_{t=1}^{T}\mathbf{z}(t,k)\mathbf{z}(t,k)^{*}.$$

8. The method of claim 6 further including the steps of estimating a spatial covariance matrix for each of the signals $\mathbf{y}(t,n)$, $n=1,\ldots,N$, and then averaging the resulting N estimated spatial covariance matrices to obtain an estimated $M \times M$ average received spatial covariance matrix $\hat{\mathbf{P}}_y$.

9. The method of claim 6 wherein the estimated average received spatial covariance matrix $\hat{\mathbf{P}}_y$ is estimated after receipt of T symbols of data in accordance with the following equation:

$$\hat{\mathbf{P}}_y = \frac{1}{TN}\sum_{t=1}^{T}\sum_{n=1}^{N}\mathbf{y}(t,n)\mathbf{y}(t,n)^* .$$

10. The method of claim 6 wherein the estimated spatial covariance matrices $\hat{\mathbf{P}}_z(k)$, $k = 1,\ldots,K$, and the average received spatial covariance matrix $\hat{\mathbf{P}}_y$ are processed to compute estimates $\hat{\mathbf{b}}_k$ for a scaled array response vector $\mathbf{b}_k$, and an estimate $\hat{\mathbf{P}}_w$ for an interference spatial covariance matrix $\mathbf{P}_w$.

11. The method of claim 10 wherein the step of processing the array response for the given mobile station to generate an antenna weighting associated with the given mobile station further includes generating a set of antenna weight vectors $\mathbf{c}(t,k) = \hat{\mathbf{P}}_w^{-1}\hat{\mathbf{b}}_k$ for $k = 1,\ldots,K$.

12. The method of claim 10 wherein the estimates for the array response $\mathbf{b}_k$ and the interference spatial covariance matrix $\mathbf{P}_w$ are determined by solving the following equations

$$\mathbf{P}_z(k) = \mathbf{b}_k\mathbf{b}_k^* + \mathbf{P}_w, \quad k = 1,\ldots,K,$$
$$\mathbf{P}_y = \mathbf{P}_w + \frac{1}{N}\sum_{k=1}^{K}\mathbf{b}_k\mathbf{b}_k^*$$

with the estimates $\hat{\mathbf{P}}_z(k)$ and $\hat{\mathbf{P}}_y$ inserted in place of $\mathbf{P}_z(k)$ and $\mathbf{P}_y$ and using an approximate iterative algorithm.

13. The method of claim 12 wherein the iterative algorithm updates stored estimates $\hat{\mathbf{b}}_k$, $k = 1,\ldots,K$, for the scaled array response vectors $\mathbf{b}_k$ in each iteration.

14. The method of claim 13 wherein the update is performed in each iteration by first estimating the interference spatial covariance matrix by summing outer products $\hat{\mathbf{b}}_k \hat{\mathbf{b}}_k^*$ and then subtracting the sum from $\hat{\mathbf{P}}_y$ to yield the estimate

$$\hat{\mathbf{P}}_w = \hat{\mathbf{P}}_y - \frac{1}{N} \sum_{k=1}^{K} \hat{\mathbf{b}}_k \hat{\mathbf{b}}_k^* .$$

and then, for each $k = 1, \ldots, K$, updating the vectors $\hat{\mathbf{b}}_k$ by the assignment

$$\mathbf{v}_k \leftarrow (\hat{\mathbf{P}}_z(k) - \hat{\mathbf{P}}_w)\hat{\mathbf{b}}_k ,$$
$$\hat{\mathbf{b}}_k \leftarrow \mathbf{v}_k / \sqrt{\mathbf{v}_k \hat{\mathbf{b}}_k} .$$

15. An apparatus for use in a base station associated with a cell of a cellular wireless communication system and having an antenna array, the apparatus comprising:

a base station receiver coupled to the antenna array and operative: (i) to estimate a spatial covariance matrix for each of a plurality of mobile stations communicating with the base station, the spatial covariance matrix for a given one of the mobile stations being determined at least in part based on a unique hopping sequence of the mobile station and providing a correlation between signals received from the mobile station at different antenna elements within the antenna array; (ii) to process the estimated spatial covariance matrices to generate an estimate of an interference matrix for the plurality of mobile stations; (iii) to estimate an array response for the given mobile station from the interference matrix; (iv) to process the array response for the given mobile station to generate an antenna weighting associated with the given mobile station; and (v) to apply the antenna weighting to a signal received from the given mobile station in order to facilitate detection of a corresponding transmitted symbol.

16. An apparatus for providing adaptation of an antenna array in a base station associated with a cell of a cellular wireless communication system, the apparatus comprising:

means for estimating a spatial covariance matrix for each of a plurality of mobile stations communicating with the base station, the spatial covariance matrix for a given one of the mobile stations being determined at least in part based on a unique hopping sequence of the mobile station and providing a correlation between signals received from the mobile station at different antenna elements within the antenna array;

means for processing the estimated spatial covariance matrices to generate an estimate of an interference matrix for the plurality of mobile stations;

means for estimating an array response for the given mobile station from the interference matrix;

means for processing the array response for the given mobile station to generate an antenna weighting associated with the given mobile station; and

means for applying the antenna weighting to a signal received from the given mobile station in order to facilitate detection of a corresponding transmitted symbol.

17. A method for providing adaptation of an antenna array in a base station associated with a cell of a cellular wireless communication system, comprising the steps of:

determining a spatial covariance matrix for each of a plurality of mobile stations communicating with the base station, the spatial covariance matrix for a given one of the mobile stations being determined at least in part based on a unique hopping sequence of the mobile station and providing a correlation between signals received from the mobile station at different antenna elements within the antenna array; and

processing the estimated spatial covariance matrices to determine an antenna weighting associated with the given mobile station;

wherein the antenna weighting is applied to a signal received from the given mobile station in order to facilitate detection of a corresponding transmitted symbol.

18. An apparatus for use with a base station associated with a cell of a cellular wireless communication system and having an antenna array, the apparatus comprising:

a base station receiver coupled to the antenna array and operative: (i) to determine a spatial covariance matrix for each of a plurality of mobile stations communicating with the base station, the spatial covariance matrix for a given one of the mobile stations being determined at least in part based on a unique hopping sequence of the mobile station and providing a correlation between signals received from the mobile station at different antenna elements within the antenna array; and (ii) to process the estimated spatial covariance matrices to determine an antenna weighting associated with the given mobile station;

wherein the antenna weighting is applied to a signal received from the given mobile station in order to facilitate detection of a corresponding transmitted symbol.

19. An apparatus for providing adaptation for an antenna array of a base station associated with a cell of a cellular wireless communication system, the apparatus comprising:

means for determining a spatial covariance matrix for each of a plurality of mobile stations communicating with the base station, the spatial covariance matrix for a given one of the mobile stations being determined at least in part based on a unique hopping sequence of the mobile station and providing a correlation between signals received from the mobile station at different antenna elements within the antenna array;

means for processing the estimated spatial covariance matrices to determine an antenna weighting associated with the given mobile station; and

weight applying means for applying the antenna weighting to a signal received from the given mobile station in order to facilitate detection of a corresponding transmitted symbol.

20. An apparatus for use with a base station associated with a cell of a cellular wireless communication system and having an antenna array, the apparatus comprising:

a processor operative: (i) to determine a spatial covariance matrix for each of a plurality of mobile stations communicating with the base station, the spatial covariance matrix for a given one of the mobile stations being determined at least in part based on a unique hopping

sequence of the mobile station and providing a correlation between signals received from the mobile station at different antenna elements within the antenna array; and (ii) to process the estimated spatial covariance matrices to determine an antenna weighting associated with the given mobile station;

wherein the antenna weighting is applied to a signal received from the given mobile station in order to facilitate detection of a corresponding transmitted symbol.